Ultra-Low Volume Change Silicon-Dominant Nanocomposite Anodes for Long Calendar Life and Cycle Life

2022 DOE VTO Annual Merit Review

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Project ID: bat530

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Overview

Timeline

- Project start: October 2020
- Project end: December 2023
- 50% complete

Budget

- Total project funding: $4.6M
  - DOE share: $3.6M
  - Sila share: $1M
- Budget Period 1 (10/20-12/21): $1.6M
- Budget Period 2 (FY 2022): $1.4M

Technical Barriers and VTO Targets

- Reduce the cost of electric vehicle batteries to less than $100/kWh
- Increase the range of electric vehicles to 300 miles
- Increase the cycle life and calendar life of next-gen Li-ion cell technologies

Partners

- PNNL: Jiguang (Jason) Zhang
- ARL: Oleg Borodin

Relevance

Impact

Sila's ultra-low volume change silicon-dominant nanocomposite materials are manufactured with scalable processes and inputs, enabling low-cost high-capacity anodes. This project applies Sila's anode technology to research, develop, fabricate, and validate next-gen Li-ion cells meeting automotive cycle life and calendar life requirements.

Objectives

- Useable energy density of >750 Wh/L
- Useable specific energy of >350 Wh/kg
- Cycle life of >1500 cycles
- Calendar life of >10 years

Approach

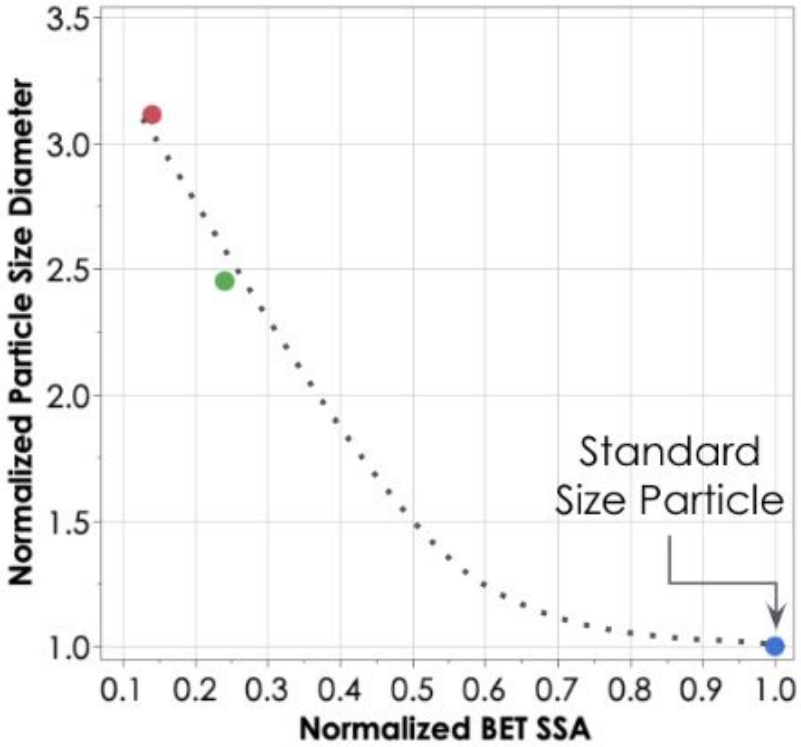
- Investigate a range of process-structure-property relationships (e.g. particle size) for Sila's anode materials
- Collaborate with PNNL and ARL to tune electrolyte compositions
- Perform initial electrochemical testing in small format cells to accelerate cycles of learning; downselect and scale up processes (multi-kg) for larger form factors

Milestone	Planned Date	Status
750+ Wh/L and 250+ Wh/kg estimated and 750+ cycles to 80% capacity projected (small format cells)	2021 (Go/No-Go)	Complete
700+ Wh/L estimated and 5+ years and 1000+ cycles to 80% capacity projected (1 Ah cells, DOE testing)	2022 (Go/No-Go)	On Track
0.5-2 Ah cells with 1500+ cycles and 10+ years calendar life (final cells delivered to DOE)	2023	On Track
750+ Wh/L and 350+ Wh/kg in 40 Ah cells	2023	On Track

Technical Accomplishments: Particle Size and BET SSA

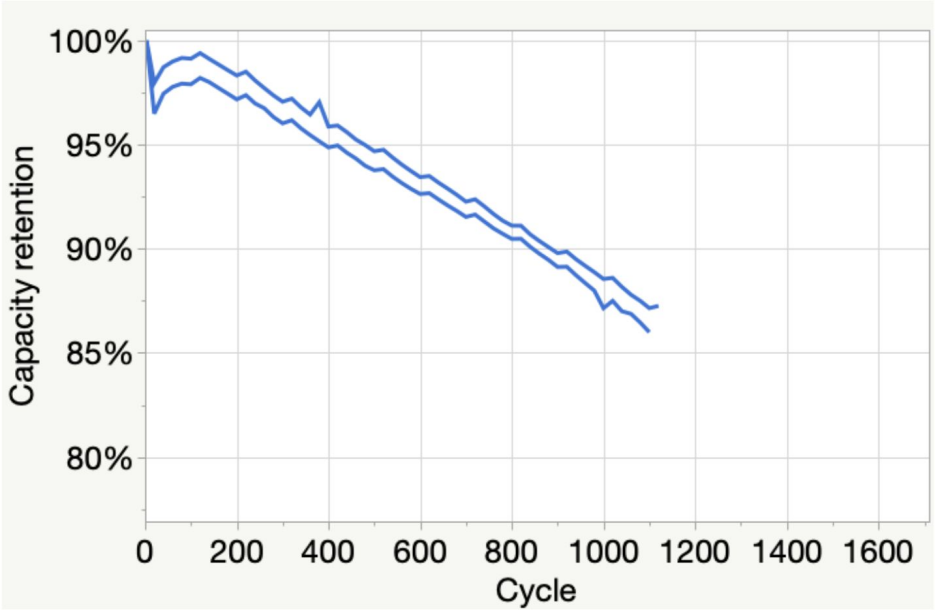
- An environmentally friendly and economically scalable low-cost process was used to synthesize Sila particles of various sizes

- Brunauer-Emmett-Teller (BET) analysis of gas adsorption data confirmed that larger particles have less specific surface area (SSA)



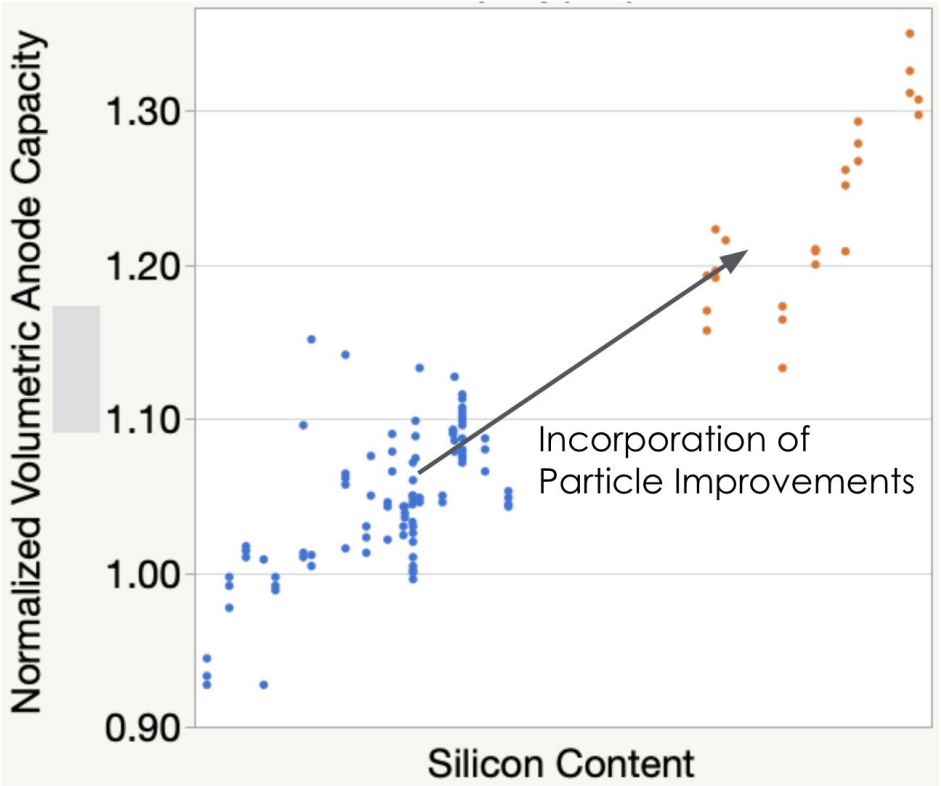
Technical Accomplishments: Cycle Life with Larger Particles

- Small format cells with larger particles showed high cycle life
- Particle size confirmed as an important parameter for achieving cycle life target



Technical Accomplishments: Increased Volumetric Capacity

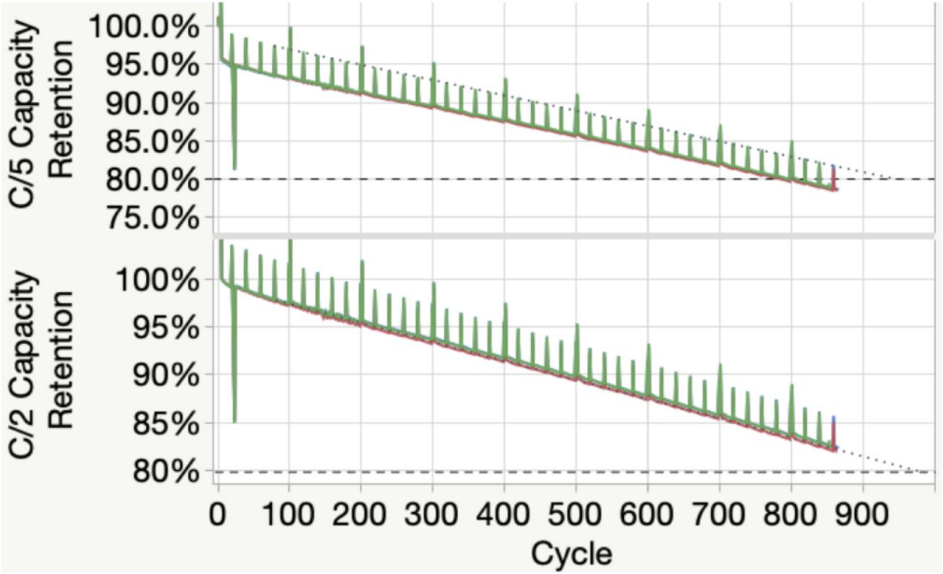
- Sila particles were synthesized with a variety of improvements
- Anode volumetric capacity increased by up to 30%
- On track for achieving energy density and specific energy targets



Technical Accomplishments: 2021 Go/No-Go Milestone

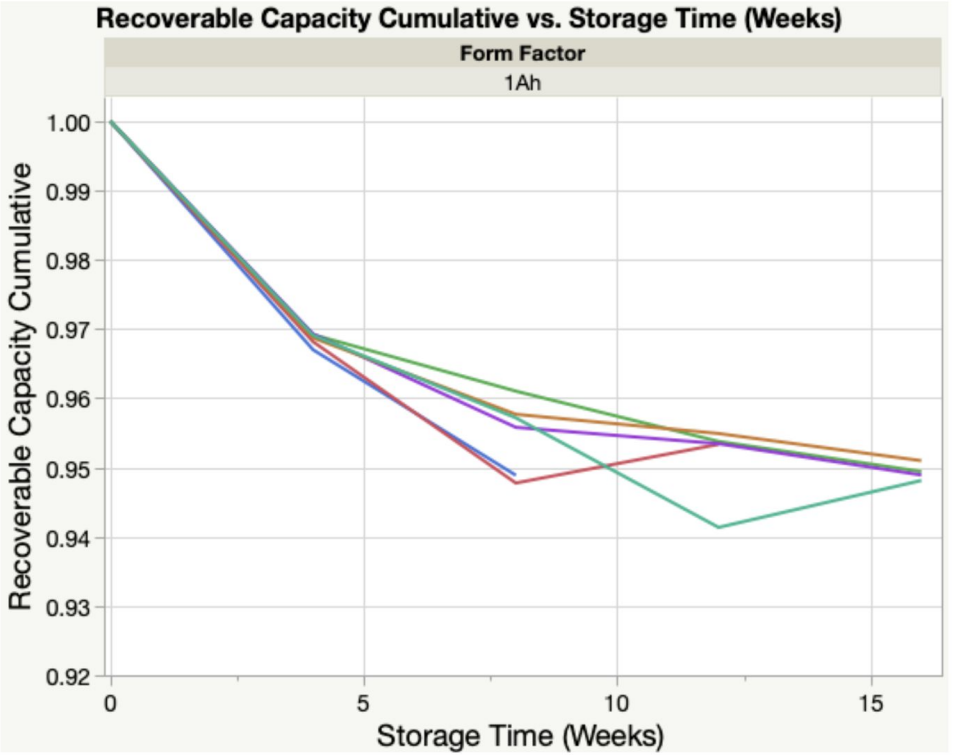
Completed Go/No-Go Milestone in small format cells

- Useable energy density (C/3) of >750 Wh/L
- Useable specific energy (C/3) of >250 Wh/kg
- 750+ cycles to 80% capacity projected



Technical Accomplishments: Calendar Life

- Demonstrated 2.5+ years of calendar life at 25°C in 0.2 Ah+ cells
- Data shown here predicts a calendar life of ~4 years in 1 Ah cells at elevated temperature
- On track for achieving calendar life target



Responses to Previous Year Reviewers' Comments

This is the first year the project has been reviewed through the AMR process

Collaborations

Pacific Northwest National Laboratory (PNNL)

- Lead: Jiguang (Jason) Zhang
- Xia Cao

Increased discharge energy and cycle life, as well as commercially relevant rate capabilities, have been demonstrated for improved Localized High Concentration Electrolytes (L-HCEs) paired with Sila anodes

Army Research Laboratory (ARL)

- Lead: Oleg Borodin

DFT modeling to screen reduction and oxidation potentials of electrolyte components, w/ and w/o Li-ion solvation

Competing mechanisms for SEI formation have been investigated and correlated with experiments on various electrolyte components

Remaining Challenges and Barriers

Continued improvements to the anode and the electrolyte are needed to achieve the final project targets

- Useable energy density of >750 Wh/L
- Useable specific energy of >350 Wh/kg
- Cycle life of >1500 cycles
- Calendar life of >10 years

Specific energy target is the most challenging - working with OEM partners and cell manufacturers to source automotive cathodes with state of the art densities

Proposed Future Research

Continue investigating a range of process-structure-property relationships for Sila's anode materials, especially:

- Surface chemistry
- Slurry optimization
- Coating density

Continue collaborating with PNNL on Localized High Concentration Electrolytes - test L-HCEs paired with Sila anodes in larger form factors

Continue modeling with ARL - focus on SEI properties and lithium desolvation energy

Any proposed future work is subject to change based on funding levels

Summary

Sila's ultra-low volume change silicon-dominant nanocomposite materials are manufactured with scalable processes and inputs, enabling low-cost high-capacity anodes

By investigating a range of process-structure-property relationships for Sila's anode materials, 750+ Wh/L and 250+ Wh/kg estimated and 750+ cycles to 80% capacity projected has been demonstrated in small format cells (completed Go/No-Go Milestone)

This project is on track to deliver next-gen Li-ion cells meeting automotive requirements:

- Useable energy density of >750 Wh/L
- Useable specific energy of >350 Wh/kg
- Cycle life of >1500 cycles
- Calendar life of >10 years